INBREEDING IN A CLOSED FLOCK[1]

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INTRODUCTION

CONSIDERABLE interest is now centered on the question of inbreeding as applied to poultry flocks bred for high fecundity. Very recently SHOFFNER (1948) has presented data on several lines of birds some inbred as much as 60 percent and others approaching zero. SHOFFNER'S data support the general thesis that close inbreeding tends to reduce hatchability, decrease egg production and to retard sexual maturity. He found no effect on body weight or egg size.

Among other things, LERNER and HAZEL (1947) made a study of the amount of inbreeding that occurred in a flock of White Leghorns over a 12-year period. Matings had been planned to avoid inbreeding and some outside stock was brought in during the first nine years of the experiment. The flock of 1935 had an average coefficient of inbreeding of 1.5 percent. There was an increase in the average coefficient on successive years up to a mean of 8.1 percent in 1941. The actual increase in the inbreeding coefficient amounted to about 2.1 percent for each generation. In this flock inbreeding was somewhat higher in the lower producing birds.

Information is desirable concerning the amount of inbreeding that actually occurs in a closed flock where selection is based on fecundity characters and where matings of closely related birds are constantly avoided.

MATERIALS AND METHODS

Rhode Island Reds bred for high fecundity since 1916 were used for study. The last five generations have been considered and pullet year performance records were used exclusively. The character and extent of the data are recorded in table 1. All stock was pedigreed.

Table 1 shows that 57 sires mated to 200 dams gave 1874 daughters for the laying houses. From the total of 1874 daughters only 1293 gave normal 365-day egg records. The rest either died or had egg records that were considered to be abnormal. The table also shows that the mean egg production of survivors did not change in five generations and that a modified type of selection of breeders may be necessary to raise the production level.

The mean degree of inbreeding in each generation was calculated by multiplying WRIGHT'S inbreeding coefficient for each family through five ancestral generations by the number of daughters housed, adding these together and dividing by the total number of daughters concerned. Tracing the pedigrees back further would have been wasted time because the inbreeding coefficient

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TABLE 1

Data on inbreeding

GENERATION	NO. OF SIRES	NO. OF DAMS	DAUGHTERS HOUSED	DAUGHTERS COMPLETING	DEAD OR ABNORMAL PERCENT	INBREEDING COEFFICIENT	EXPECTED COEFFICIENT RANDOM MATING	MEAN PRODUCTION
1942	6	24	201	146	27	5.33	2.60	233
1943	10	27	265	162	39	2.85	4.31	232
1944	12	39	386	286	26	3.73	5.67	230
1945	14	56	515	365	29	4.37	6.78	224
1946	15	54	507	334	34	4.07	7.84	232
Totals	57	200	1874	1293				

would have increased insignificantly. Table 1 records the inbreeding coefficients of each generation, the number of daughters housed, number completing the year, percent dying or giving abnormal records and mean production.

Table 1 indicates that there was a low degree of inbreeding in each generation and that there was no tendency for the amount of inbreeding to increase in successive generations. The percentage of pullets dying or showing abnormal egg records was not consistent with the degree of inbreeding in the flock as a whole.

The calculated coefficients of inbreeding by WRIGHT's (1931) formula for a reasonably large population mated at random were higher than the actual

TABLE 2

Degree of inbreeding and egg production

INBREEDING COEFFICIENT	NO. OF FAMILIES	TOTAL NUMBER COMPLETING	AVG. FAMILY SIZE BIRDS COMPLETING	MEAN WEIGHTED PRODUCTION
0	10	64	6.4	239
.01– 3	101	701	6.9	232
3– 5	42	255	6.1	235
5– 7	15	93	6.2	222
7– 9	13	85	7.1	217
9–11	3	17	5.7	212
11–13	1	4	4.0	195
13–15	5	30	6.0	219
15–17	2	10	5.0	223
17–19	1	1	1.0	132
19–21	1	2	2.0	190
21–23	1	5	5.0	228
23–25	0	—	—	—
25–27	5	26	5.2	209
Totals	200	1293		

coefficients in the last two generations. This fact indicates that by careful selection of breeders on the pedigree basis, inbreeding may be held at a low level without introducing new stock.

INBREEDING AND EGG PRODUCTION

Inbreeding ranged from zero to slightly over 25 percent in the different families. In table 2 the total population in five generations is classified with respect to degree of inbreeding.

Table 2 indicates that mean annual egg production was highest in the families with no inbreeding. When the inbreeding coefficient was below five percent, the decline in egg production was not very great. When the inbreeding coefficient was above five percent there was a significant decline in mean egg production. In general, there is some evidence of declining production with higher degrees of inbreeding, but there are exceptions.

EFFECTS OF INBREEDING ON FECUNDITY CHARACTERS

Such fecundity traits as age at sexual maturity, incidence of winter pause, winter intensity, egg weight to January 1 and persistency have an important relation to the number of eggs laid. In table 3 the possible effect of degree for inbreeding on these traits is considered.

TABLE 3

Effects of inbreeding on fecundity characters in daughters

PERCENT INBRED	MEAN AGE AT FIRST EGG		PERCENT WITH WINTER PAUSE		MEAN WINTER CLUTCH		MEAN EGG WT. TO JAN. 1		MEAN ANNUAL PERSISTENCY	
	No.		*No.*		*No.*		*No.*		*No.*	
0	86	181	81	38.3	81	3.5	82	54.2	64	353
.01– 3	923	196	857	40.3	861	3.3	860	55.4	701	352
3– 5	357	200	322	45.3	324	3.3	328	55.3	244	353
5– 7	135	198	126	52.4	126	2.9	128	55.8	104	347
7– 9	123	199	113	42.5	114	2.9	116	56.0	85	349
9–11	24	194	21	57.1	21	2.7	21	55.3	17	344
11–13	6	187	4	75.0	4	2.9	3	56.3	4	349
13–15	47	196	44	36.4	44	3.2	44	53.4	30	353
15–17	11	190	10	60.0	10	3.0	10	53.2	10	337
17–19	1	219	1	100.0	1	1.5	1	54.8	1	286
19–21	5	181	4	100.0	4	2.8	4	49.6	2	321
21–23	9	235	9	77.8	9	2.3	8	56.0	5	348
23–25	—	—	—	—	—	—	—	—	—	—
25–27	36	215	35	62.9	35	2.4	33	53.88	26	339

The data in table 3 suggest that degree of inbreeding does not greatly affect the age at sexual maturity. There was a slight tendency for maturity to be slowed up by a more intimate degree of inbreeding but the inbred birds could not be considered as late in sexual maturity. Certainly the effects of the degree of inbreeding concerned in this flock were not as great as the effects of recessive genes *e* and *e′* (HAYS 1945).

The incidence of winter pause was lowest in the non-inbred pullets and there was a significant increase in pause incidence as inbreeding became more intense.

Winter intensity measured by the mean winter clutch size was definitely affected by inbreeding. Here the regression approached linearity. From the data available, there appears to be a consistent decline in clutch size as the inbreeding coefficient increased. In view of this fact, it would appear that inbred birds are likely to lay fewer eggs because of lower intensity.

TABLE 4

Degree of inbreeding and laying house mortality

DEGREE OF INBREEDING	DAUGHTERS HOUSED	DAUGHTERS COMPLETING	% MORTALITY
0	88	64	27.2
.01– 3	978	701	28.3
3– 5	382	255	33.2
5– 7	134	93	30.6
7– 9	132	85	35.6
9–11	24	17	29.2
11–13	6	4	33.3
13–15	47	30	36.2
15–17	12	10	16.7
17–19	1	1	0
19–21	5	2	60.0
21–23	10	5	50.0
23–25	—	—	—
25–27	40	26	35.0
	1859*	1293	

* This total includes only families in which some daughters completed normal egg records.

Our data furnish no evidence that inbreeding affects egg size adversely. This is in agreement with the observations of SHOFFNER (1948) and many other investigators.

Degree of inbreeding appeared to have no effect on persistency of laying. Since persistency or length of the laying year has been shown to be the most important single character affecting annual egg production, it is evident that inbreeding does not reduce egg production by shortening the laying year.

In general, the data in table 3 appear to indicate that the decline in egg production associated with inbreeding is attributable largely to lowered intensity of laying and to a lesser extent to a higher incidence of winter pause.

INBREEDING AND MORTALITY

If the degree of inbreeding affects the laying house mortality, this evidence should appear in table 4 which includes the total population.

With few exceptions mortality tends to increase as inbreeding increases. Unfortunately the number of daughters in the higher inbred groups from 10 percent upward is too small for statistical reliability. With adequate numbers of daughters ranging from 0 to 10 percent inbred, there appears to be a slow but consistent increase in mortality as the degree of inbreeding increased.

DISCUSSION AND SUMMARY

In a completely closed flock of Rhode Island Reds a very low degree of inbreeding appeared in five generations. The maximum occurred in the first generation at 5.33 percent inbreeding and there was something of a decrease in degree of inbreeding through the period. These data do furnish evidence that a flock of from 200 to 500 pullets may be produced in a closed flock over a period of time without close inbreeding provided the stock is pedigreed so that close matings may be avoided. In fact the maximum degree of inbreeding was 5.33 percent while 6.1 percent inbreeding results from single first cousin matings.

Our data suggest that there is likely to be a decline in egg production when matings equivalent to single first cousin matings are made. Matings as close as a single generation of half-brother sister matings (12.5 percent inbreeding) may affect egg production adversely. Only five families showed a degree of inbreeding comparable with a single generation of full brother sister matings (25 percent inbreeding). The mean egg production of these daughters was 209.

As far as fecundity traits are concerned, the degree of inbreeding has some effects. Age at sexual maturity is slightly increased by closer inbreeding. The incidence of winter pause rises with increased inbreeding. Winter intensity appears to be very significantly reduced by inbreeding. Egg size is not affected but persistency may be very slightly reduced by inbreeding.

A gradual decline in viability accompanies an increased degree of inbreeding. Mean mortality was about 27 percent in the non-inbred group compared with a value of 35 percent when the inbreeding coefficient rose to 12 percent or higher.

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